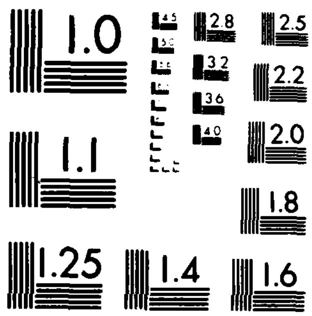
AD-A122 788 SURVEY OF TRANSONIC FLOW RESEARCH IN CHINA(U) FOREIGN TECHNOLOGY DIV WRIGHT-PATTERSON AFB OH Z ZHENG 18 OCT 82 FTD-ID(RS)T-1077-82 1/1

UNCLASSIFIED F/G 20/4 NL

END
DATE FILMED
8-83
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

FTD-ID(RS)T-1077-82

FOREIGN TECHNOLOGY DIVISION

SURVEY OF TRANSONIC FLOW RESEARCH IN CHINA

by

Zheng Zhichu

82 12 28 149

FTD-ID(RS)T-1077-82

EDITED TRANSLATION

FTD-ID(RS)T-1077-82 18 October 1982

MICROFICHE NR: FTD-82-C-001331

SURVEY OF TRANSONIC FLOW RESEARCH IN CHINA

By: Zheng Zhichu

English pages: 8

Source: Lixue yu Shijian, Vol. 4, Nr. 1, 1982, pp. 70-71

Country of origin: China
Translated by: Randy Dorsey
Requester: FTD/TQTA
Approved for public release; distribution unlimited.

GRAPHICS DISCLAIMER

All figures, graphics, tables, equations, etc. merged into this translation were extracted from the best quality copy available.

SURVEY OF TRANSONIC FLOW RESEARCH IN CHINA

Zheng Zhichu
(Institute of Mechanics, Chinese Academy of Sciences)

Transonic flow research in China began in the 1950s. It should be said that we were still somewhat involved in the building of organizational strength and were laying the foundation for small scale test equipment. Today, thirty years later, at a time when transonic flow is at the high tide of research internationally, the First All-China Symposium on Transonic Flow was convened in Sian from 26-31 May 1981, jointly sponsored by the Chinese Society of Aerodynamics and the Aviation and Space Society. It was the summarizing and exchanging of primary systems technology for the entire field of transonic flow in China in recent years; as can be seen from the organizations participating and the contents of the papers which were presented, this symposium indicates that the contingent of transonic flow research workers in China has already basically taken shape, theoretical and experimental research work has already begun to develop and, furthermore, definite progress has been made. It is expected that in the not too distant future, China will be able to make some contribution to transonic flow research. The forty-five papers which were read at the symposium can be summed up as three types: numerical calculations, analytical methods, and experimental techniques. These are also the three important avenues of transonic flow research which have unfolded internationally. Of these, there were 24 papers on numerical

calculations, 11 on analytical methods, and 10 on experimental techniques. A brief introduction to these different areas of research is given below, from which we can see recent developments in transonic flow research in China.

Transonic flow is a hybrid problem which is rather difficult to handle mathematically. In the early 1970s research was begun abroad on numerical calculation methods for transonic flow aerodynamics, and at present the use of difference methods is rather widespread. These are divided into two general types:

1. Time correlation methods in which mixed equations are unified into hyperbolic equations by introducing a time variable and which use the unified difference scheme for treatment.

2. Mixed difference methods which employ different difference schemes based on the different characteristics of mixed flows in the subsonic region and the supersonic region. During approximately the same period, corresponding research was very rapidly developed in China which, from the standpoint of methods, has not gone beyond the scope of those described above, and, from the standpoint of treatment techniques, has combined the general characteristics of specific instances considered. This development work is divided into the following general areas:

Steady State, Inviscid External Flow Calculation

This is an important field of numerical calculation of transonic flow which was developed in China, and which also has substantial content. Transonic flow about various objects is probed beginning with working out actual engineering conditions: the theory of small perturbations has achieved widespread use in transonic flow research but for different conditions the method has its limitations. In recent years, revised small perturbation equations have become widely used for calculating flow fields of various object shapes, such as employing large perturbations in the x direction and small perturbations in the direction of y and z; second-order small

perturbations; total velocity potential equations for dealing with blunt leading edges. In addition, there are a number of methods which, by rational treatment of object surface boundary, distant field boundary, and vortex plane boundary conditions, we can use a number of standard profiles as well as actual profiles in engineering applications and calculate the flow at given angles of attack and at given inflow Mach numbers.

The Study of Improved Calculation Methods

Rapidity of convergence, savings in machine time and high accuracy are important criteria in judging the quality of calculation methods. In the last few years, as a result of flow field calculations on standard aerodynamic profiles such as wings, bodies of revolution, and wing-fuselage combinations, a number of methods of treatment have been found which satisfy the above requirements. For example, at subsonic and supersonic speeds both selection of different relaxation factors, even so far as artificially changing relaxation factors, and rational selection of initial fields, can increase the speed of calculation convergence for a fixed aerodynamic profile under conditions of fixed inflow. In addition, loose nets gradually made more dense and nonequidistant nets have also been studied, which can shorten machine time and improve the accuracy of calculations.

Calculation of Nonstationary External Flow

There is a close relationship between the study of transonic non-stationary problems and its aerodynamic unstable phenomenon. With regard to steady flow, there has not been much research in the area in China. The solution to inviscid, two-dimensional nonstationary flow problems using the finite volume method and the alternate direction implicit difference method was introduced at the symposium, and a number of results were obtained in the calculation of the flow fields of airfoils such as circular arc aircraft wings and double parabolic arcs.

Calculation of Internal Flow

Here we refer to the investigation of three-dimensional transonic flow with shock waves in high-speed impeller mechanisms. This problem has also had some numerically calculated results internationally. In recent years, some research work has also been done in China, and we should say that now we are also in the exploratory stage of the method. One tentative idea is attempting to use the relaxation solution of the transonic velocity potential equation for flows about two-dimensional cascades and oscillating non-stationary cascades. Another idea is to use the "time propulsion finite area method," which was proposed abroad, for calculation of flow about cascades. The two methods have both achieved initial results under certain conditions. It can be expected that this will be a domain of scientific research having a large number of research topics.

In summary, it can be seen that the finite difference method is already widely used in China for the calculation of transonic flow fields for airfoils, bodies of rotation, intake ducts, cascades, and entire fuselages, and some of the results coincide well with foreign theories and experiments.

Since numerical calculations require the expenditure of large amounts of machine time, when $M_\infty \to 1$, they are either difficult to converge or the results differ, and engineering units also urgently need a simpler method which can be used for calculation of selected shapes, therefore methods are very urgently needed for expanding the analysis of transonic flows. Below a few of the principal methods are briefly introduced:

<u>The streamline perturbation method</u>. Assuming a small angle of intersection between the compressible streamline and the incompressible streamline at an arbitrary point in the flow field, and with the isopotential line of compressible potential flow and the streamline as the coordinates, a simplified flow factor equation is obtained. This method was first successfully used for calculating

nozzle internal flow and was then extended to external flow about two-dimensional cylinders, elliptical cylinders, and axisymmetric spheres and ellipsoids, obtaining subcritical and supercritical flow fields. Furthermore, we began to understand the relationship between the transonic flow fields of thick bodies and thin bodies.

The integral equation finite element method proposed at the symposium uses embedding analysis solutions to treat leading edges and the transonic integral equations established abroad for two-dimensional thin wings were extended to three dimensional, thereby decreasing computer capacity and reducing the amount of calculation work. Fairly good results have been obtained using the finite element method in the calculation of rectangular wings and constant-chord, swept-back wings. Besides this, the simpler Galerkin finite element method is widely used for calculating one-dimensional nozzle problems with shock waves and two-dimensional supercritical boundary flow problems with shock waves. This work has begun to explore the effects of applying the finite element method to transonic flow.

In addition, it was also proposed to use the "physical numerical model" concept to find the solution to transonic flow problems. The idea of this is not to set-up flow equations, but to divide the flow field into several tubes of flow, assign initial values, calculate the parameters of two adjacent surfaces using simple one-dimensional isentropic relationships or shockwave relationships, and find solutions until repeated iteration has reached a result which satisfies distant field and object surface boundary conditions. This paper presents the results of calculations of symmetric airfoils and two-dimensional tubes of flow. Another paper proposed using the streamline coordinate system to establish a set of transonic gas dynamics equations, and deriving shockwave relationships expressed as streamline coordinates. It can cause grid dimensions to differ at each point depending on calculation requirements and it is not necessary to adopt rotational differences when finding solutions for flow field supersonic regions. In the future we hope to see the results of this method of calculation.

All in all, this field studies rather dynamic methods of thinking and dealing with problems, the areas involved are rather broad and it can be anticipated that some of these methods will develop into calculation methods for systematic solution of transonic flow.

At present, in China the main test instrument for transonic flow is still the wind tunnel. In recent years, we have acquired large, rather advanced transonic wind tunnels with circulation instruments and digital recorders (such as the 1.2x1.2 m^2 wind tunnel). Besides this, various technological measures have been applied to medium and small facilities already built (such as the 0.3x0.3 m^2 and the 0.6x0.6 m^2 transonic wind tunnels) thus enhancing the quality of the wind tunnel flow field and thereby obtaining test data of rather high accuracy.

Many wind tunnels in China employ relatively advanced obliquely perforated walls and experimental research has been conducted on the effects of the opening ratio of the perforated walls at different inflow Mach numbers, and the effect of two and four wall perforation on the quality of the flow field, and the optimum layout was obtained for certain operating conditions. Some people have also looked into the effect of covering the obliquely perforated wall surface with metal mesh with respect to reducing background noise, in the hope of obtaining accurate test results during the simulation of certain nonstationary aerodynamic phenomena.

With respect to the shortcoming of insufficient length of the test section uniform region of many existing transonic wind tunnels in China, tests have been conducted looking into ways of shortening the acceleration region.

Based on a comparison of tests of 25 accelerator sections, the optimum layouts were selected which had the best overall indices. There was also a paper which introduced methods on using different ways to establish uniform transonic flow fields, such as regulating the degree of opening between the second throat and the exhaust

valve and obtaining the regulating parameters in different Mach number ranges which satisfy requirements. There were also effective methods for reducing the influence of the sidewalls while carrying out two-dimensional airfoil tests. Due to the realization of the above technological measures, the quality of the flow fields obtained in many wind tunnels in China has reached or surpassed the criteria stipulated by the annual aerodynamic conferences in the '60s.

In recent years, with the appearance of large aircraft and the development of space technology, the effect of Re numbers must be taken into consideration in transonic flow. Around the world, many new facilities have appeared for carrying out transonic flow experiments. For example, refrigerated wind tunnels, Ludwig tubes, ballistic targets and microwave tubes. Introduced at the symposium were the circumstances of the development of transonic flow tests in China using ballistic target facilities, the advantages of utilizing facilities without sustaining interference and the effects of small wind tunnels, providing a spherical flow field and coefficient of drag in the vicinity of M=1. In addition, there are also a number of crucial problems which must be solved with regard to building Ludwig tubes, such as increasing the air reservoir tube wall boundary layer, facility minimum start-up time, and the aerodynamic loads on the test section panel adjusting plates. Calculations were carried out on the layout and its theoretical properties in order to build these facilities in China without a hitch from the outset.

Experience accumulated over many years in the area of experimental research in transonic flow, which has brought the use of wind tunnels into full play and has strengthened the coordination of various experimental methods, is an important aspect of the total in-depth solution of transonic flow problems.

In the next few years, transonic flow research will inevitably be a problem of utmost interest to people in the field of fluid mechanics. The direction of attack, which is the gradual approach of velocities toward $M_\infty \to 1$, and gaining a clear understanding of

variations in flow in the vicinity of $M_\infty=1$ are crucial. And strengthening experimental observations is very important to this problem. With respect to flow, the treatment of flows which are both viscid and have shock wave and boundary layer interference and the development of calculations for flow about combination bodies having an angle of attack are the directions of efforts. There was very little work on viscid flow at this symposium, only one paper dealing with the treatment of airfoil boundary layers. However, by taking actual flow into account, this area must be penetrated to some extent. Taking into account dynamic effects, close attention must be given to transonic nonstationary research. With the development of aviation and space industry the effect of Re number merits close attention, therefore while improving simulation testing technology, consideration should also be given to building new test equipment. Calculation of flow about transonic blade cascades is an important work and its progress is related to the development of a dynamic revolution and energy savings. From the viewpoint of developing production and strengthening national defense, a large number of using departments urgently hope to have various simpler and accurate engineering calculation methods. Within the next few years, transonic flow research in China will expand into these areas and theoretical and experimental research will make great advances.

Subsequent periodic meetings of the Transonic Flow Symposium will play a big part in the development of China's aviation, missiles, engines, and strategic weapons as well as the development of basic and applied sciences.

this
are
nce
on
ts.
only
ers.
be
ects,
search.
ect of
simulation
uilding
ade
o the
om the
al defense,
arious
in the
d into
make

mposium
, missiles,
of basic

END

DATE
FILMED

2-83

DTIC